Climate Change and Public Health

Climate Change and Public Health:

Unravelling the Conundrum

Edited by

Nitha B.

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PREFACE

The intersection of climate change and public health represents one of the most pressing challenges today. As global temperatures rise, weather patterns shift and ecosystems transform, the repercussions on human health are becoming increasingly evident. From the spread of infectious diseases to the exacerbation of chronic conditions, from food and water insecurity to the mental health toll of climate-related disasters, the linkages between a warming planet and public health are complex, multifaceted in a deeply interconnected nexus. This book seeks to explore these intricate relationships, offering a comprehensive examination of how environmental changes are reshaping the landscape of human well-being. The idea for this book emerged from a growing recognition that while climate change is often discussed in terms of environmental degradation, economic costs and geopolitical instability, its profound implications for health remain underemphasized in public discourse. Policymakers, healthcare professionals and communities worldwide are grappling with the cascading effects of climate change, yet many lack the necessary tools to understand, mitigate and adapt to these challenges. The goal is to bridge the gap by presenting a synthesis of scientific research, policy analysis and real-world case studies that illuminate the diverse ways in which climate change influences health outcomes. By integrating perspectives from diverse fields, the book aims to provide a nuanced understanding of the challenges and opportunities at the intersection of climate and health. The conundrum of climate change and public health is complex, but by unravelling it together we can forge a path towards a healthier and more sustainable world.

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CHAPTER 1

A WARMING WORLD: PUBLIC HEALTH IN THE ERA OF THE CLIMATE CRISIS

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Abstract

The accelerating impacts of climate change have placed unprecedented pressures on public health systems worldwide, making the health of individuals and communities increasingly vulnerable to environmental changes. The most obvious consequences of global warming are extreme weather events, unprecedented climatic change and the development of vector-borne diseases, all of which have a significant impact on both physical and mental health. Vulnerable groups, especially those in low-income areas, are disproportionately impacted by these climate-driven shifts, which exacerbates already-existing health inequities and highlights the need for radical reforms to public health policies and practices. To lessen the effects of climate change and guarantee fair health outcomes for everyone, it is imperative to address the relationship between public health and climate change. Numerous health conditions are made worse by climate change, ranging from respiratory and heat-related illnesses to mental health problems and the spread of infectious infections. Mortality rates have gone up due to heatwaves and extended exposure to high temperatures, particularly for the elderly and people with underlying medical issues. Since warming temperatures and shifting precipitation

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patterns provide more ideal conditions for disease-carrying organisms, vector-borne illnesses including Lyme disease, dengue and malaria have spread geographically. Additionally, the looming existential threat of climate change has given rise to phenomena such as “eco-anxiety,” particularly among younger generations. The intersection of physical and mental health challenges demonstrates the multifaceted impact of climate change on public health, requiring an integrated and holistic response. Thus, the paper is an attempt to explore the public health issues encircling in the era of global climate change.

Keywords*: Climate Change, Global Warming, Vector-Borne Diseases, Public Health*

Introduction

Climate change is a major threat to global biodiversity and public health, as rapid effects of climate change have put public health systems around the world under previously unheard-of strain, making people's and communities' health more susceptible to environmental changes (Román-Palacios and Wiens, 2020; Rajput *et al.,* 2023). Extreme weather events, previously unheard-of climatic change and the emergence of vector-borne diseases are the most evident effects of global warming and they all have a substantial influence on mental and physical health (Caminade *et al.,* 2019). Beyond environmental deterioration, these changes have complex and frequently harmful direct effects on human health. Extreme weather events, heatwaves, rising sea levels and ecosystem changes are all examples of climate-related phenomena that have increased health hazards, from vector-borne diseases to heat-related ailments. With effects that go well beyond environmental deterioration, climate change has become one of the 21st century's most significant issues. It has a significant, complex and pressing effect on public health.

Deforestation, industrialization and the combustion of fossil fuels are all contributing to the rise in global temperatures, which is changing ecosystems and increasing the frequency and severity of extreme weather events. Human health is significantly impacted by these changes, which have both direct and indirect effects on people and communities. The health impacts of a warming globe are widespread and uneven, ranging from vector-borne disease transmission and the mental health toll of climate anxiety to heat-related ailments and respiratory disorders brought on by air pollution (Hayes *et al.,* 2018; Piracha and Chaudhary, 2022). The potential of climate change to worsen already-existing health inequities is

among its most concerning features, especially in developing countries. The impact is disproportionately felt by vulnerable groups, such as indigenous peoples, low-income communities and residents of areas prone to natural disasters who often lack the resources, infrastructure and access to healthcare. Thus, the paper is an attempt to explore the public health issues encircling in the era of global climate change.

The global climate crisis: A public health emergency

The global climate crisis has emerged as one of the most significant public health emergencies now, with far-reaching consequences for human health and well-being. As the planet continues to warm due to anthropogenic activities, the health impacts of climate change are becoming increasingly evident, affecting populations across the globe, irrespective of geographic realm. An increase in heat-related diseases as a result of rising temperatures will generate more and more burden, especially for susceptible populations like the elderly and people with underlying medical conditions (Kenny *et al.,* 2010; Petkova *et al.,* 2014). In addition to causing immediate harm and death, extreme weather events like hurricanes, floods and wildfires can cause long-term mental health problems, displacement, and disruptions in healthcare services. Additionally, air pollution, which is connected to respiratory conditions like asthma and chronic obstructive pulmonary disease (COPD), is made worse by climate change (D'Amato *et al.,* 2014). Higher pollen levels and an increase in the frequency and severity of wildfires worsen air quality and increase the risks to respiratory health. The shifting climate also influences the dynamics of vector-borne diseases, as changes in temperature and precipitation patterns affect the distribution and behavior of disease-carrying organisms like mosquitoes, rodents and ticks which results in the potential spread of diseases to new regions, increasing the burden on public health systems (Mojahed *et al.,* 2022). Additionally, climate change threatens food security and nutrition, as extreme weather events disrupt agricultural production and supply chains. Water scarcity and contamination further exacerbate health risks, leading to waterborne diseases and malnutrition, particularly in low-income and marginalized communities that are often the most affected by these changes. Fig. 1 summarizes human health impacts of climate change.

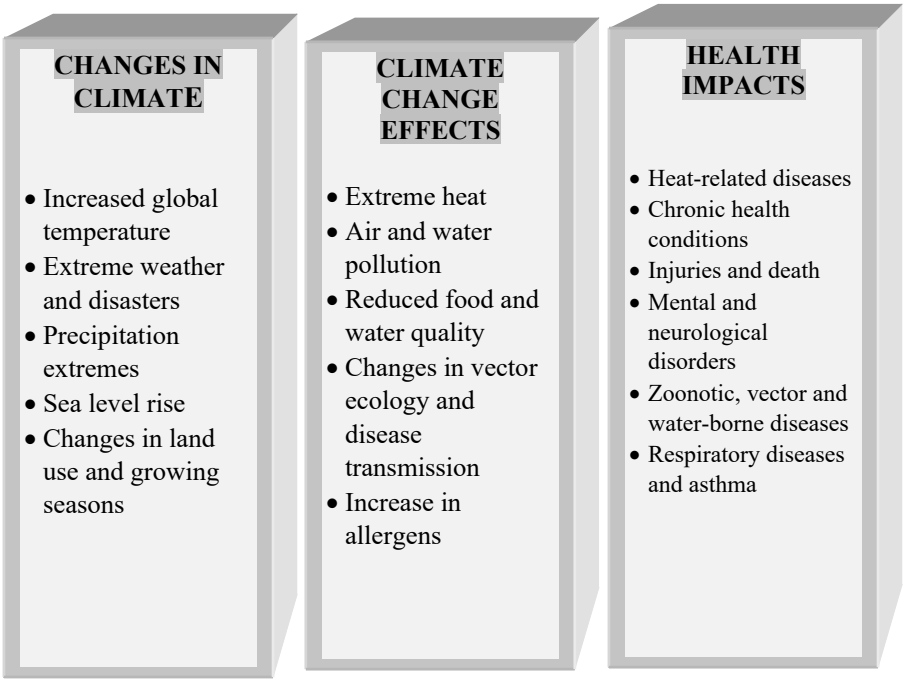

Fig. 1: Human health impacts of climate change

Climate change is a health emergency and the magnitude of the situation is well illustrated by WEF (2024), where the estimates of morbidity and mortality from climate-intensified natural disasters add up to about 15 million deaths, over two billion lost healthy life years and $12.5 trillion in economic losses by 2050. The world and healthcare ecosystems are at risk of becoming unstable because of the threat posed by global warming. The detrimental effects of climate change on the health of the planet will be characterized by six weather-related catastrophes by 2050. Mortality will account for only 21% of the health burden, however long-term disabilities and health issues that arise after the climate catastrophe will account for 79%. The intersection of climate change and public health highlights the urgent need for a comprehensive and coordinated response, as vulnerable populations face compounded risks due to socioeconomic disparities and limited access to healthcare resources.

Physical health impacts of climate change

With significant riotous effects on human health, climate change is one of the most important worldwide issues the world is currently witnessing. Because environmental systems are interdependent, disturbances to ecosystems will unavoidably affect human welfare and endanger populations everywhere. The impacts of climate change are widespread and affect health outcomes in a variety of geographic locations and demographic groups. The rise in heat-related diseases is one of the most obvious effects of climate change. Heat stress, dehydration and heatstroke are caused by prolonged exposure to high temperatures and are especially dangerous for vulnerable groups, including the elderly, children, and people with underlying medical conditions (Leyk *et al.,* 2019). The major physical health impacts of climate change are given below:

- **Heat-related illnesses and mortality:** One of the most obvious effects of climate change on human health is the rise in global temperatures. Heat-related diseases such as heat exhaustion, heatstroke and cardiovascular stress have significantly increased as a result of prolonged heatwaves (Patel *et al.,* 2022). Particularly at risk are vulnerable populations, including the elderly, children, and people with underlying medical conditions. As global temperatures continue to rise, the World Health Organization (WHO) estimates that heatwaves cause tens of thousands of premature deaths each year.
- **Air pollution and respiratory disorders:** Increased levels of particulate matter, ground-level ozone and emissions from wildfires are some of the ways that climate change makes air pollution worse. Respiratory disorders like bronchitis, asthma and chronic obstructive pulmonary disease (COPD) are exacerbated by poor air quality (Kent, 2023). Particularly detrimental effects on health are felt in urban areas, where there is a concentration of vehicle and industrial pollutants. Furthermore, wildfire smoke has become a growing public health concern due to extended droughts and rising temperatures.
- **Vector-borne and water-borne diseases:** Shifts in temperature and precipitation patterns have expanded the geographic range of vector-borne diseases such as Malaria, Dengue fever and Lyme disease. Warmer climates create ideal breeding conditions for vectors like mosquitoes and ticks, increasing the transmission of these diseases (Hunter, 2003). Additionally, extreme weather

events, including floods and hurricanes, often contaminate water supplies, leading to outbreaks of waterborne diseases such as cholera and dysentery.

Mental health impacts of climate change

In addition to being an environmental emergency, climate change poses a serious threat to the mental health of affected populations. The psychological effects of these shifts are becoming more noticeable as the globe struggles with warming temperatures, harsh weather and changing ecosystems. Beyond money losses and physical health, climate change has an impact on social cohesiveness, emotional stability and people's capacity to deal with future unpredictability (Clayton *et al.,* 2017). The effects of climate change on mental health outcomes are intricate and wide-ranging, whether they are caused by sudden occurrences like natural catastrophes or more gradual, sneaky processes like environmental degradation. Survivors of natural catastrophes, such as hurricanes, floods and wildfires, frequently struggle with loss, grief and trauma which can lead to conditions such as post-traumatic stress disorder (PTSD), anxiety and depression, which are exacerbated by the disruption of communities and livelihoods (Cianconi *et al.,* 2020; Heanoy and Brown, 2024). The emotional burden of losing homes, loved ones or access to essential resources can have long-term psychological effects, particularly in vulnerable populations with limited access to mental health support. In addition, the climate change-induced events, such as forced migration and resource scarcity, can strain social cohesion and lead to isolation. Displacement disrupts social networks and support systems, while competition for limited resources often fuels conflicts which contribute to a growing mental health crisis, particularly in already vulnerable populations.

Health inequities amplified by climate change

In addition to being an economic and environmental issue, climate change is a major contributor to health disparities. Its effects are not uniformly dispersed; rather, they exacerbate already-existing gaps in health outcomes by disproportionately affecting vulnerable populations. Women, children, indigenous populations, low-income communities and people with disabilities are among the marginalized groups that frequently suffer the most from climate-related health risks because of their limited access to resources, healthcare, and social support networks, as well as their increased exposure to environmental hazards. This uneven burden emphasizes how

social justice and climate change are intertwined, underscoring the necessity of equity-centered strategies for tackling climate-related issues.

Because they are ill-prepared to prepare for or recover from such disasters, impoverished communities are often devastated by extreme weather events like hurricanes, floods and heatwaves. Climate change also intensifies health inequities through its influence on disease patterns. Populations in low-resource settings often lack the means to combat diseases effectively, further widening health disparities. The mental health toll of climate change is similarly inequitable where communities are facing cultural loss, experiencing heightened levels of trauma, anxiety, and depression. In addition, women and girls are particularly vulnerable to the health impacts of climate change. In many regions, they bear the primary responsibility for securing food, water, and fuel, tasks that become increasingly challenging in the face of climate disruptions. Additionally, women are often at greater risk of exploitation and violence during climate-induced displacement, further compromising their physical and mental well-being (Schuster *et al.,* 2024). The effects of climate change on health vary significantly between urban and rural areas (Zelenakova *et al.,* 2015). Urban populations are more exposed to heatwaves and air pollution due to the urban heat island effect and high concentrations of emissions. In contrast, rural communities often face challenges related to agricultural disruptions, limited access to healthcare facilities, and inadequate infrastructure to cope with extreme weather events.

Conclusion

The significant effects of climate change on public health are becoming more and more obvious as the globe warms incessantly. Extreme weather events, changing ecosystems and rising temperatures are not only environmental problems; they are also pressing public health emergencies that require prompt attention. From heat-related ailments and the spread of infectious diseases to respiratory disorders made worse by air pollution and mental health issues brought on by climate anxiety and displacement, the health effects are wide-ranging. These problems are interrelated rather than isolated, exacerbating preexisting vulnerabilities and disproportionately impacting underprivileged communities. Strong adaptation plans that put resilience in communities and healthcare systems first must be combined with mitigation initiatives like switching to renewable energy sources and cutting greenhouse gas emissions. It is crucial to guarantee access to safe housing, wholesome food and clean water, especially in areas most

vulnerable to the effects of climate change. The health of humanity is inseparable from the health of the planet. By recognizing the profound links between environmental stewardship and public well-being, we can build a future that safeguards both. Urgent action, informed by science and guided by compassion, is essential to protect public health and ensure a sustainable, equitable future for generations to come. Thus, climate change is both a public health crisis and an existential threat, demanding urgent and comprehensive action. Its effects on mental and physical health as well as the escalation of already-existing disparities highlight the necessity of revolutionary approaches that put sustainability, equity and resilience first. Societies can lessen the negative effects of global warming on health while laying the groundwork for a healthier, more just future by supporting preventive measures, investing in climate-resilient health systems and encouraging international cooperation. In addition to being morally required, addressing the relationship between public health and climate change is essential in attaining environmental sustainability and global health.

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CHAPTER 2

HISTORICAL PERSPECTIVES ON CLIMATE CHANGE IMPACTS

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Abstract

The historical perspective of climate change impacts on ecology shows that there is an intricate relationship between the shifts in the environment and the development of society. Through research it has been revealed that the field of historical climatology has expanded to new areas and time horizons, using various sources and methods to reconstruct the past climates and their impact on the environment. The climate in the course of the last century has been warmer, as is evident from the records. A biotic and physical response on a regional scale was initiated due to these climatic fluctuations. While deciphering historical variability, climate variability poses several issues. This need for considering climate impacts

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in the comparison of modern ecosystems with historical ones is one of the difficulties. This is particularly the case when comparisons are made with a view of identifying the aspects that led to disparities or when coming up with models that would help in the rehabilitation of existing environments. The periods before the settlements, which are characteristic of the Little Ice Age, attract a lot of attention in historical studies. Thus, it is logical to conclude that the ecosystems that were inferred for these historical periods adapted to climates that are not currently in force and the consequences of management strategy should be changed. The twentieth century was the warmest on record, and there were changes in the observable impacts of global warming including sea level rise, changes in precipitation, and an increase in the occurrence of extreme weather events. Ecosystems, biodiversity, agriculture, and human health have been affected as well by these changes. Climate impacts have increased in frequency and severity in the last few decades beyond natural variability and as a result of human activity, records and scientific data showing that this is the case. Furthermore, different places have experienced a number of consequences, which depend on the place, the people, and their ability to cope with the consequences. Most of these effects are normally experienced by sensitive groups like indigenous people and those living on coastlines. This has the consequence of exacerbating existing injustices and creating challenges for the formation of adequate solutions. For the future, it is crucial to understand the historical developments of the effects of climate change to make proper decisions and develop proper policies. In order for societies to be able to navigate the challenges offered by climate change and strive for a better sustainable future they need to learn from the responses and successes that have happened in the past. The objective of this chapter is to discuss the historical view of climate change outcomes in relation to the greenhouse effects, ice age, radiative forcing, anthropogenic aerosols, solar variability, and volcanic activity.

Keywords*: Climate Change, Global Warming, Greenhouse Effect, Climate Impacts, Historical Studies*

Introduction

Climate is a troublesome concept for people to handle, as normally we are accustomed to perceiving climate in terms of short-term fluctuations or weather, and our recall is biased toward such extremes as heat waves, cold snaps, and storms (Hulme, 2009). Weather, on the other hand, refers to the short-term states or conditions of the atmosphere, while climate is the

long-term variability of weather parameters. Fluctuations in climate normally occur after tens of thousands of years; therefore, human civilization has developed during a period of climate stability (Oreskes, 2004). This implies that structures, cities and even the human body are not equipped to handle relatively fast fluctuations of climate in a few decades or centuries. It is important to understand that the entire world is in the process of an unprecedented shift to the urban setting. Cities cover less than 2 percent of the earth's surface, yet they are home to more than half of the world's population; as recently as 1900, this proportion was only 14 percent and is now projected to rise to 60 percent by 2030. This rapid rise will be mainly in the developing countries. Asia and Africa are projected to have the highest growth of the urban population which is expected to be 64% and 56% of the total population in 2050, respectively (United Nations, 2014). Climate change will impact the performance of buildings, the built environment and the comfort and health of the people in cities. In this chapter, the author will discuss the history and scientific evidence of climate change and briefly discuss the effects of climate change based on the most recent climate predictions. In addition, historical context enables one to understand the degree of impact that humans have placed on the environment in the past. Pollution, deforestation, and the expansion of agriculture have played a part in the current climate of the world.

Knowledge of these historical processes enables one to find out how modern environmental problems have developed and emphasizes the fact of the interaction of various processes that have shaped the current state of the environment. It also highlights the need for climate change mitigation as the decisions made today define the future of tomorrow. Thus, it can be stated that utilizing historical perspective in climate change research is not just useful, but rather crucial (UN-Habitat, 2011). Using the examples of climate history, paleoclimate data, and previous human experience of climate changes, this chapter stresses the importance of historical approaches to understanding current climate issues. Learning the historical effects of climate change enhances the knowledge of the current climate change challenge, which shows that the problems are not new but are the continuous interaction between societies and the environment. This perspective is especially important when it comes to creating the right strategies and the right approaches to addressing the many-faceted problem of climate change. The purpose of this chapter is to review the historical perspective of climate change consequences concerning greenhouse effects and the ice age etc.

Importance of historical perspective in current climate policies

Technological advancement is essential, while the knowledge of previous society's responses to climate change is also relevant when developing climate policies. Catastrophic occurrences, such as the doom of ancient cultures because of environmental pressures, call for a policy system that is flexible and adaptable. The disappearance of the Mayan civilization, which many modern researchers believe was due to a lack of rainfall and excessive logging, is an essential lesson on properly utilizing natural resources (Ford, 2024).

The Kyoto Protocol and the Paris Agreement, which took into account the lessons learned from earlier accords, are two examples of agreements that set the stage for the present climate policy. The 1997 Kyoto Protocol sought to impose legally binding, precise emission reduction objectives on rich nations; however, it did not establish a comparable threshold for developing nations (Pan, 2005). This has led to the signing of the Paris Agreement (2015), where countries can set targets within their abilities to cut emissions. The increasing importance of adaptation and nexus in the Paris Agreement also reflects the growing awareness of policies dealing with mitigation and climate change consequences, including rising sea levels and increasing natural disasters (Droge, 2016). General knowledge of historical views can assist decision-makers in understanding the policy's far-sightedness. The lack of proper care for air pollution and deforestation during industrialization have significantly impacted climate change. Current climate policies must consider the accumulated emissions stock and damaged or destroyed ecosystem services. This is especially relevant in a world of carbon budgets where there is a set limit to the amount of CO_2 the world can emit if the worst of climate change is to be avoided.

Historical perspectives show how it is requisite to foster international relations. One of the most successful international regimes for addressing environmental challenges, the Montreal Protocol (1987), exemplifies the fact that global cooperation is possible for successful environmental action (Sarma and Andersen, 2011). The outcome of the Montreal Protocol is quite favorable for today's treaty negotiations as it explains that even if nations have their self-interests, they should cooperate to produce far-reaching environmental impacts. Today's difficulties in combating climate change strengthen the relevance of historical practice and signal the necessity to continue further cooperation.

Pre-industrial climate variability

Understanding pre-industrial climate change helps to assess the effects of natural climate changes on the societies of people. Looking at climate history, such as the Little Ice Age and the Medieval Warm Period, we get to know how climate change affected agricultural practices, economic activities and society. Such events therefore clearly demonstrate the strength and frailty of societies in the face of climatic changes and can therefore be used as a reference point in the fight against today's climate change.

The Little Ice Age (14th to 19th Century)

The Little Ice Age was a period of cooler global temperatures which occurred between the 14th and 19th centuries with a range of climatic impacts especially in the Northern Hemisphere. It was characterized by an increase in the size of mountain glaciers, cold winter seasons and short growing seasons (Matthews and Briffa, 2005). The fluctuations in climate during the Little Ice Age had drastic impacts on the agricultural field and food production, resulting in crop losses, inadequate food supplies, and high death rates caused by hunger and sickness.

Another outcome of the Little Ice Age was the Great Famine of 1315-1317 in Europe that was caused by a series of crop failures due to the cooling climate. The price of grains soared and this led to famine and social unrest (Campbell, 2010). The decrease in agricultural production also had a negative impact on the economy. The scarcity of food increased competition and hence more taxes and other difficulties for the lower classes (Parker, 2013). For example, climate change in Scandinavia and the North Atlantic region changed the temperature and made the environment unsuitable for the Norse colony in Greenland that was forced to abandon the place by the 15th Century (Dugmore *et al.,* 2012). The Little Ice Age is also related to cultural and societal factors. For instance, in Europe, the cold climate saw the emergence of winter fairs on the frozen rivers and lakes, new types of clothing and architecture suited for the climate (Pfister, 2007).

The Medieval Warm Period (9th to 14th century)

The Medieval Warm Period was warmer than today, especially in the North Atlantic, during the 9th-14th centuries AD (Mann *et al*., 2009). This period was suitable for the growth of agriculture and the development of

the colonies; for instance, Greenland, where the Norsemen had developed farming communities during the warm climate. The conditions of the Medieval Warm Period were conducive to agriculture across Europe, which saw an increase in population and economic development. The growing agricultural surplus made it possible to build large cathedrals and establish trade relations with different regions of Europe and distant countries (Hoffmann, 2014). The civilization of this period can be evidenced by the increase in art, architecture, and culture, and the expansion of cities. Variability of the Medieval Warm Period was also not without geopolitical consequences. Competition for resources was affected by the expansion of the agricultural lands as well as the growth of populations in Europe, for instance the Norman Conquest of England in 1066 (Bartlett, 1993). Also, the warm climate facilitated the Norse into the North Atlantic, but the cooling of the Little Ice Age led to the failure of Norse colonies in Greenland (Diamond, 2005).

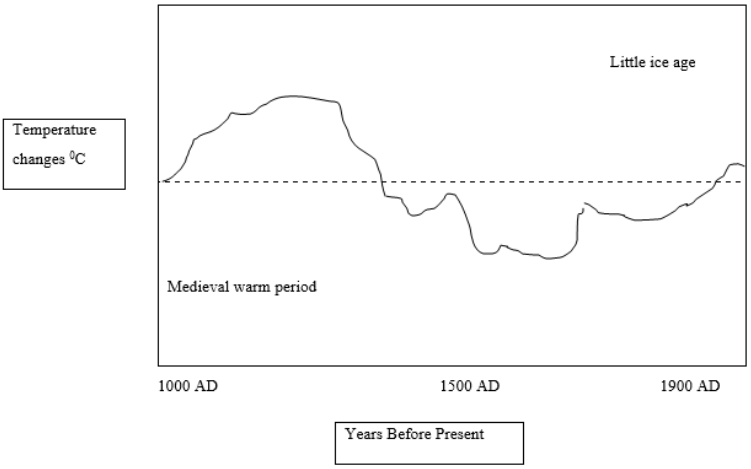

Fig. 1: This figure shows The Medieval Warm Period and the Little Age (Jones *et al.,* 2009)

Societal impacts of pre-industrial climate events

The effects of the Little Ice Age and the Medieval Warm Period are well documented and they affected society in many ways. These periods of

climate variability impacted food security, economic stability and social organization and demonstrated how human societies are sensitive to climate change. The Great Famine of 1315-1317 is a clear example of how climate change through the Little Ice Age led to hunger, social unrest and even political revolution (Jordan, 1996). On the other hand, the Medieval Warm Period favored farming and commerce, thus boosting the economy and the arts. But this was not without some problems. Climatic fluctuations such as droughts and other forms of climate variability and change during this period were also seen to have reached a level that human beings could not adapt to, for instance the case of the Ancestral Puebloan society in the American Southwest (Benson *et al*., 2007).

Appreciating the effects of pre-industrial climate change also helps to appreciate the long-term environmental changes that need to be taken into consideration when dealing with current climate issues. The history of the Little Ice Age and the Medieval Warm Period show that societies have to be prepared for climate change and adapt to it based on the strengths and weaknesses of the existing civilizations. These historical perspectives can help us in the present day as we come to terms with the present realities of climate change.

The industrial revolution and its impact

The Industrial Revolution refers to the changes that started in the mid-18th Century and are considered significant in history. This period was characterized by the shift from hand work to production by the use of machine energies from coal, a fossil fuel, bringing along with it the Industrial Revolution, urbanization, and tremendous economic development.

Industrialization and greenhouse gas emissions/carbon role

The Industrial Revolution was primarily fueled by the abundant availability of coal, which provided a cheap and efficient energy source for steam engines and factories (Mohajan, 2019). As industrial activities expanded, the demand for coal surged, leading to significant increases in CO_2 emissions. Before the Industrial Revolution, atmospheric CO_2 levels were relatively stable. By the mid-19th Century, emissions began to rise sharply due to the increase (MacCracken, 2008).

During this period, Svante Arrhenius, a Swedish scientist, first proposed that the increasing concentration of CO_2 in the atmosphere could lead to global warming, a concept now known as the greenhouse effect (Anderson *et al.,* 2016). Using coal as the primary energy source not only emitted CO_2, which exacerbated global warming. The rise in CO_2 emissions during the Industrial Revolution marked the beginning of the Anthropocene, a time when environmental and climatic changes have been mostly caused by human activities (Steffen *et al.,* 2011).

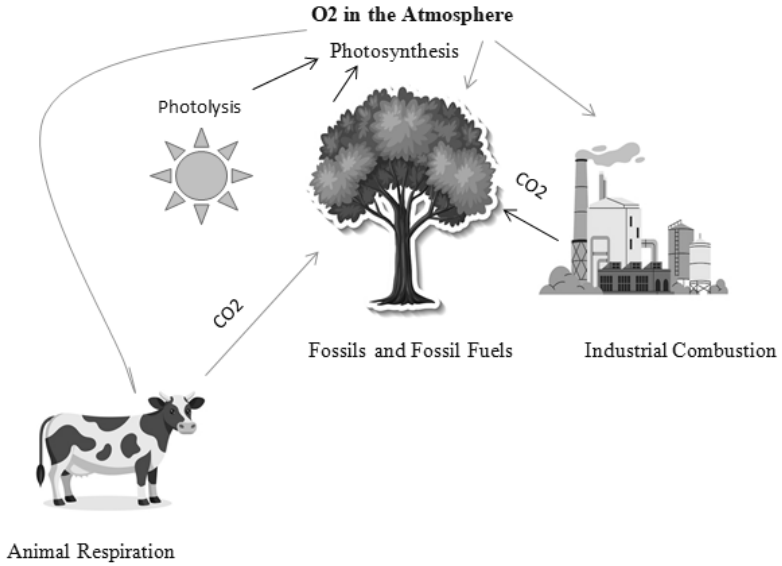

Fig. 2: This figure shows Greenhouse Gas Emission

Environmental consequences of industrial growth

The environmental impact of the Industrial Revolution extended far beyond greenhouse gas emissions. One of the most significant consequences was widespread deforestation, as forests were cleared for factories, cities, and agricultural expansion. A net one percent annual loss of forest area was observed in 28 nations and regions. Over the last 10 years, the regions with the greatest net loss of forests include Oceania, Africa (3.4 million hectares year), and South America (about four million hectares annually) (Venkatram, 1990). Rapid industrialization and urbanization have resulted

in air, water, and soil pollution. Large volumes of pollutants, such as nitrogen oxides (NOx) and sulfur dioxide (SO_4), were discharged by factories into the atmosphere, causing acid rain, which severely damaged ecosystems and agricultural systems. Another significant consequence was the rise of urban air pollution. Cities like London and Manchester became notorious for smog directly resulting from industrial activities. The environmental degradation effects of the Industrial Revolution went unnoticed, primarily until the onset of the 20th Century. Environmental degradation issues, such as biodiversity loss, ecological degradation, and global climate change, qualities of today's world, were put into place during this period through enhanced carbon emissions, deforestation, and dirty sources of energy (Stradling and Thorsheim, 1999).

Climate change in the 20th Century

In the modern period the twentieth Century, climatic change has been experienced with much intensity due to activities such as the Industrial Revolution, the expansion of urban centers, and the use of fossils.

Post-World War II economic boom and environmental cost

The historical era that followed WWII was marked by sudden economic growth, especially in countries of the West; this refers to the post-war economic boom or the period of the Great Acceleration (Holm, 2012). This economic growth came with industrialization and production, increasing dependency on hydrocarbon resources, so oil and natural gas. Automobile culture, suburbanization, and consumerism were some of the effects that contributed to energy demand, which increased significantly and, subsequently, the emissions of greenhouse gases (Martin, 2013).

The 1950s witnessed an unprecedented increase in industrial activities, with the world's CO_2 emissions on a steep rise. This fostered significant economic development during this period, though it negatively impacted the environment (Pfister, 2010). Many forests were cut down to accommodate new industries, and the rapid growth of cities and large-scale farming using chemical fertilizers and pesticides degraded the soil and polluted water sources. From the late 1960s, people began perceiving the actual cost of this economic growth through pollution of the air and water, loss of habitat or natural resources, and many other effects on ecosystems worldwide (Commoner, 2013). Climate change was made

worse by the growth and industrialization of emerging nations in the latter part of the 20th century. China and India are good examples of countries that went through a rapid process of urbanization, which entailed the consumption of plenty of coal and a destructive influence on forested areas. These developments caused the levels of atmospheric CO_2 to increase, which enhanced the problem of global warming (Wu *et al.,* 2017).

The role of international organizations (e.g., IPCC)

The government and public began to recognize in the 1970s that environmental damage is a cost of economic expansion. Global leaders and scientists joined together to combat climate change, including global warming. Since its inception in the latter half of the 20th Century, climate governance on a global scale has undoubtedly advanced.

Organization	Role	References
IPCC	The IPCC was established by the UN and WMO to provide impartial information on climate change-related issues and possible solutions to decision-makers. A variety of SRES emission scenarios indicate that temperatures will rise by around 0.2°C every decade for the next 20 years. An estimated 0.1°C of warming would occur every ten years, even in the event that all greenhouse gas and aerosol concentrations were kept at 2000 levels. Mitigating climate change was the main goal of the Intergovernmental Panel on Climate Change's establishment in 1988.	(Change, 2007)
UNFCCC	The United Nations Framework Convention on Climate Change (UNFCCC), established in 1992, is another important international institution. For the first time in history, world leaders signed an	(Obergassel *et al*., 2016).